US006983924B2

(12) **United States Patent**
Howell et al.

(10) **Patent No.: US 6,983,924 B2**
(45) **Date of Patent: Jan. 10, 2006**

(54) **COMPLIANT, ORTHO-PLANAR, LINEAR MOTION SPRING**

(75) Inventors: **Larry L. Howell**, Orem, UT (US); **Scott Thomson**, Provo, UT (US); **Jason Alan Briscoe**, Provo, UT (US); **John J. Parise**, Lauderhill, FL (US); **Shae Lorenc**, Idaho Falls, ID (US); **John B. Larsen**, Provo, UT (US); **Curtis R. Huffmire**, Provo, UT (US); **Nathan Burnside**, Provo, UT (US); **Troy A. Gomm**, Provo, UT (US)

(73) Assignee: **Brigham Young University**, Provo, UT (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 95 days.

(21) Appl. No.: **10/258,568**

(22) PCT Filed: **Apr. 25, 2001**

(86) PCT No.: **PCT/US01/13351**

§ 371 (c)(1),
(2), (4) Date: **Jun. 30, 2003**

(87) PCT Pub. No.: **WO01/81785**

PCT Pub. Date: **Nov. 1, 2001**

(65) **Prior Publication Data**

US 2004/0021123 A1 Feb. 5, 2004

Related U.S. Application Data

(60) Provisional application No. 60/199,905, filed on Apr. 26, 2000.

(51) **Int. Cl.**
F16F 1/34 (2006.01)

(52) **U.S. Cl.** **251/118**; 251/902; 267/158; 267/160

(58) **Field of Classification Search** 251/118, 251/902; 267/160, 158
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,029,097	A *	6/1912	Atkinson	251/902
1,359,279	A *	11/1920	Sansoucy	251/902
1,826,597	A *	10/1931	Brecht	267/162
3,575,342	A	4/1971	Puster	
3,577,184	A	5/1971	McNeel et al.	
3,602,490	A	8/1971	Mueller et al.	
3,742,441	A	6/1973	Riley	
3,817,488	A	6/1974	Mack	

(Continued)

Primary Examiner—John Bastianelli
(74) *Attorney, Agent, or Firm*—Thorpe North & Western

(57) **ABSTRACT**

An ortho-planar spring has a platform movably coupled to a base and being movable linearly with respect to the base along at least a portion of an axial direction perpendicular to both a base surface and a platform surface. A resilient and flexible connecting structure is connected to and between the base and platform. The connecting structure is bendable to develop (i) an axial force along the axial direction to bias the platform in a stable position with respect to the base, and (ii) non-axial forces which substantially sum to zero to preserve the orientation of the platform with respect to the base. Thus, the spring is very compact and does not have rotation between the deflecting ends. The spring may be associated with a valve opening, and a button for restricting flow through the valve opening, to bias the button at a position with respect to the valve opening.

56 Claims, 8 Drawing Sheets